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Memorandum 2047 (June 2015). ISSN 1874-4850. Available from: http://www.math.utwente.nl/publications
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Valuation under randomness of players in coalitions, with an application to the Dutch filmindustry

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June 4, 2015

Abstract

In this paper we introduce a new and objective method to measure the quality of proposals from collaborating professionals. The quality or potential of a professional in a proposal is influenced by a random environment. We derive a (numerical) value which measures the potential of a proposal by collaborating professionals. Furthermore, we provide the best linear unbiased estimator of the potential of a professional.

We apply our method to estimate the values of Dutch films, from collaborating producers and filmmakers, released in 2010. Our method is shown to obtain good results. Furthermore, as a by-product we rank producers, directors and screenwriters of Dutch films up to 2011. These rankings are concluded to be fair.

1 Introduction

Many institutes evaluate proposals from collaborating professionals. Such proposals may be research proposals by collaborating researchers, tenders by consortia of firms, proposals for new films by collaborating producers and filmmakers, and so on. To evaluate these, a good method is needed to determine the potential of the proposals. We introduce a new and objective method to measure this potential.

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Our method first measures the potential of the collaborating professionals. Thereafter, these qualities are combined to determine the potential of the proposal by the collaboration. We apply our method to determine the potential of proposals for new films in the Netherlands.

In the literature, several research fields study the potential of collaborations. The field of citation analysis studies the scientific performance of groups or scholars [7]. Public procurement evaluates tenders, with the goal of achieving high quality and a low price [2]. Sports science investigates team sports efficiency, among others, usually with econometric methods [6]. Research on investment projects includes measuring or ranking these projects. [1] assigns a value to each investment project based on future technological impacts and patent citation analysis. [13] surveys performance measurement, evaluating the efficiency of individual and organizational performance.

The quality or performance of motion pictures is usually measured by box-office revenues [9], so after the release. Hence, one way to determine the quality of a movie proposal, is forecasting the box-office revenue. Most papers consider forecasting after the release of the movie (e.g. [14]). A few consider marketing models to forecast the revenues after production of the movie but before it has been released [4].

More recently, the forecasting of box-office revenue before the production or the release of the movie is considered. This is done with artificial neural networks [8, 16]. These models use input variables like MPAA rating, competition, star value, and genre. Their goal is to correctly classify the success of a movie in one of several categories.

The skills of people involved in the production of movies are considered in [12]. The author finds that film performance of German movies is influenced by the skills of people that are closely related to the management, development and realization of the film project. [10] investigates the impact of track record and financial resources on the commercial and artistic success of cinema projects, and the relation between the commercial and artistic performance of films of the US cinema. The commercial track record of a director is shown to have a positive impact on the commercial success of a movie. Also, past artistic success turns out to be a good predictor of artistic performance. [3] study the effect of reputations in the film industry to obtain investment capital. These reputations are based on past performance of the individuals involved. The authors investigate the commercial and the artistic reputation of producers and directors.

The contribution of our work is as follows. We introduce a new and objective method to evaluate proposals from collaborating professionals. In particular, we apply our method to the Dutch filmindustry by measuring the potential of proposals for new movies based on the potential of the film team. This measure will be a (numerical) value, and not a

category.

The outline of this paper is as follows. Section 2 introduces our model of cooperating individuals that are involved in multiple projects. Thereafter, we estimate the potential of an individual in section 3. We apply our model to the evaluation of film proposals for the distribution of subsidies by the Netherlands Film Fund in section 4.

2 Model

Let $\mathcal{P} = \{p_1, \ldots, p_N\}$ be a set of N players, and $C \subset \mathcal{P}$ a coalition of players. The set $\mathcal{C}$ of all coalitions is the power set of $\mathcal{P}$. Let $\mathcal{F} = \{f_1, \ldots, f_M\}$ denote a set of projects, and $C(f) \in \mathcal{C}$ the coalition that carries out project f, $f \in \mathcal{F}$. A coalition may carry out multiple projects, and a player may be a member of multiple coalitions simultaneously, but each project is carried out by a unique coalition. The set of projects involving player p is $\{f : p \in C(f)\}$. We assume projects are completed in periods $t = -1, -2, \ldots$, that is, 1, 2 or more periods ago, and that each project $f \in \mathcal{F}$ has a unique period t_f of completion.

The value of a project f carried out by coalition $C(f)$ may be under influence of a random environment. We *assume* that this influence is common for all projects. We are interested in the value that an individual player has contributed to a project, and in statistical estimation or prediction of the value of a project to be completed at $t = 0$.

The value $x_{p,f}$ of player p in project f represents the potential of player p. The randomness in this value is due to the influence of the random environment. We *assume* that

$$x_{p,f} = \mu_p(t_f) + u_{p,f}, \quad p \in C(f), \quad f \in \mathcal{F},$$

where $\mu_p(t_f)$ is the potential of player p in period t_f, which represents the quality (e.g. skills) that player p contributes to a project completed in period t_f, and $u_{p,f}$ is the influence of the random environment on the value for player p and project f. Both $x_{p,f}$ and $u_{p,f}$ are random variables. The assumption that the influence of the random environment is common for all projects implies that the $u_{p,f}$ are i.i.d. random variables. We *assume* that

$$\mathbb{E}[u_{p,f}] = 0.$$

Then

$$\mathbb{E}[x_{p,f}] = \mu_p(t_f)$$

and

$$\mathbb{V}\mathrm{ar}(x_{p,f}) = \mathbb{V}\mathrm{ar}(u_{p,f}),$$

which we denote by $\sigma^2 := \mathbb{V}\mathrm{ar}(u_{p,f})$.

We are interested in prediction of the value V_f of a *proposed project* f to be completed in period 0, $t_f = 0$. This prediction is based on the realizations of previous projects in periods $t = -1, -2, \ldots$, discounting these values to period 0. For this we need the value $X_{p,f}$ in period 0 of player p in project f:

$$X_{p,f} = \mu_p + U_{p,f}, \quad p \in C(f), \quad f \in \mathcal{F}. \tag{1}$$

This value consists of the potential $\mu_p := \mu_p(0)$ of player p, and the randomness $U_{p,f}$ in the value of the project discounted from period t_f to period 0.

Example: A model for the influence of the random environment

To evaluate the value of project $f \in \mathcal{F}$ at time 0, we *assume* that randomness $U_{p,f}$ is characterized by the current experience w_p of player p, and the amount of time elapsed from completion of project f to period 0 as represented by $v_{p,f}$:

$$U_{p,f} = v_{p,f} u_{p,f} / w_p, \quad p \in C(f), \quad f \in \mathcal{F}.$$

The more experience a player has, the less noise there is on the value of the player in the project. Further, when more time has elapsed since the project was completed, the more noise there is.

As the $u_{p,f}$ are i.i.d. with $\mathbb{E}[u_{p,f}] = 0$ and $\mathbb{V}\mathrm{ar}(u_{p,f}) = \sigma^2$, we obtain that the $U_{p,f}$ are independent random variables with

$$\mathbb{E}[U_{p,f}] = 0 \tag{2}$$

and

$$\mathbb{V}\mathrm{ar}(U_{p,f}) = \sigma^2 v_{p,f}^2 / w_p^2.$$

Further, $\mathbb{E}[X_{p,f}] = \mu_p$ and $\mathbb{V}\mathrm{ar}(X_{p,f}) = \mathbb{V}\mathrm{ar}(U_{p,f})$. □

Let $\mathcal{F}_0 \subset \mathcal{F}$ be the set of proposed projects to be completed in period 0. The predicted value V_f of a project $f \in \mathcal{F}_0$ is assumed to be the sum of the values of the contributions of the players involved in project f:

$$V_f = \sum_{p \in C(f)} X_{p,f}.$$

In section 3 we describe how to *estimate* the personal contributions of the players. Given these estimates, we may rank proposals $f \in \mathcal{F}_0$ based on past performance, taking into

account different levels of information. We consider ranking according to the total potential of coalitions, and ranking taking into account the uncertainty in the estimation of the potentials.

For each coalition $C(f)$, $f \in \mathcal{F}_0$, the *potential* of a coalition $C(f)$ for project f is

$$\mathbb{E}[V_f] = \mathbb{E}[\sum_{p \in C(f)} X_{p,f}] = \sum_{p \in C(f)} \mu_p$$

We may rank proposals according to increasing potential $\mathbb{E}[V_f]$.

Ranking according to the potential of coalitions does not take into account the uncertainty in the potentials of players. To refine our ranking, taking this uncertainty into account, we propose to rank projects according to the probability that the value of the coalition exceeds a constant c:

$$\mathbb{P}(V_f > c).$$

In an alternative setting, players may have different weights in a coalition. This may happen, for example, if one player has a smaller contribution than another player. To this end, let $\delta_{p,f}$ denote the weight of player p in project f. The value of project f is then a weighted sum of the values of the players:

$$V_f^\delta = \sum_{p \in C(f)} \delta_{p,f} X_{p,f}.$$

We may rank proposals according to the mean value of the project,

$$\mathbb{E}[V_f^\delta] = \mathbb{E}[\sum_{p \in C(f)} \delta_{p,f} X_{p,f}] = \sum_{p \in C(f)} \delta_{p,f} \mu_p,$$

or according to the probability that the weighted value exceeds a constant c,

$$\mathbb{P}(V_f^\delta > c).$$

Example continued: ranking under normal randomness

When randomness is due to a large number of smaller effects, invoking the Central Limit Theorem suggests that $u_{p,f}$ has a normal distribution. When we *assume* that randomness $u_{p,f}$ has a normal distribution, then

$$u_{p,f} \sim \mathcal{N}(0, \sigma^2).$$

This implies that

$$U_{p,f} \sim \mathcal{N}(0, \sigma^2 v_{p,f}^2 / w_p^2).$$

As a consequence,

$$X_{p,f} \sim \mathcal{N}(\mu_p, \sigma^2 v_{p,f}^2 / w_p^2),$$

and for $f \in \mathcal{F}_0$

$$V_f^\delta \sim \mathcal{N}(\textstyle\sum_{p \in C(f)} \delta_{p,f} \mu_p, \sum_{p \in C(f)} \sigma^2 \delta_{p,f}^2 v_{p,f}^2 / w_p^2).$$

We thus rank proposals $f \in \mathcal{F}_0$ according to their potential

$$\mathbb{E}[V_f] = \sum_{p \in C(f)} \delta_{p,f} \mu_p,$$

or according to the probability

$$\Phi\left(\left(c - \sum_{p \in C(f)} \delta_{p,f} \mu_p\right)\left(\sqrt{\sum_{p \in C(f)} \sigma^2 \delta_{p,f}^2 v_{p,f}^2 / w_p^2}\right)^{-1}\right),$$

with $\Phi(x)$ the standard normal distribution function. □

3 Estimation of the potential of a player

In this section we develop the best linear unbiased estimator for the potential μ_p of player p, $p \in \mathcal{P}$, and the common noise σ^2.

Let $D_p = \{d_{p,f} : 0 \leq d_{p,f} \leq 1,\ f \in \mathcal{F}; \sum_{\{f: p \in C(f)\}} d_{p,f} = 1\}$ be a set of coefficients for the projects of player p. Define the estimator $\widehat{m(d_p)}$, $d_p \in D_p$, by

$$\widehat{m(d_p)} := \sum_{\{f: p \in C(f)\}} d_{p,f} X_{p,f}, \quad p \in \mathcal{P}.$$

By (1) and (2), this is a *linear unbiased estimator* of the potential μ_p. As the variables $U_{p,f}$, $p \in \mathcal{P}$, $f \in \mathcal{F}$, are independent, the variance of this estimator is

$$\mathbb{V}\mathrm{ar}(\widehat{m(d_p)}) = \sum_{\{f: p \in C(f)\}} d_{p,f}^2 \mathbb{V}\mathrm{ar}(U_{p,f}).$$

Further, note that the following property holds:

$$\sum_{\{f: p \in C(f)\}} d_{p,f} \mathbb{E}[(X_{p,f}(t) - \widehat{m(d_p)})^2] = \sum_{\{f: p \in C(f)\}} (d_{p,f} - d_{p,f}^2) \mathbb{V}\mathrm{ar}(X_{p,f}(t)). \tag{3}$$

The *best linear unbiased estimator* (BLUE) $\widehat{\mu}_p$ of the potential μ_p is the estimator with minimal variance among the linear unbiased estimators $\widehat{m(d_p)}$. The set $D_p^* = \{d_{p,f}^*,\ f :$

$p \in C(f)\}$, $D_p^* \subset D_p$, that minimizes the variance of $\widehat{m(d_p)}$ solves

$$\begin{aligned} \min \quad & \sum_{\{f:p\in C(f)\}} d_{p,f}^2 \mathbb{V}\mathrm{ar}(U_{p,f}) \\ \text{s.t.} \quad & \sum_{\{f:p\in C(f)\}} d_{p,f} = 1; \quad 0 \le d_{p,f} \le 1, \quad p \in C(f),\ f \in \mathcal{F}. \end{aligned}$$

Example continued: BLUE of the potential of a player

In our example, we have observed that the variables $U_{p,f}$, $p \in \mathcal{P}$, $f \in \mathcal{F}$, are independent, and have variance $\mathbb{V}\mathrm{ar}(U_{p,f}) = \sigma^2 v_{p,f}^2 / w_p^2$. As a consequence, the variance of the estimator $\widehat{m(d_p)}$ is

$$\mathbb{V}\mathrm{ar}(\widehat{m(d_p)}) = \sum_{\{f:p\in C(f)\}} d_{p,f}^2 \sigma^2 v_{p,f}^2 / w_p^2.$$

To obtain the BLUE, observe that σ^2/w_p^2 is constant with respect to project f. The coefficients in D_p^* that minimize the variance of $\widehat{m(d_p)}$ solve

$$\begin{aligned} \min \quad & \sum_{\{f:p\in C(f)\}} d_{p,f}^2 v_{p,f}^2 \\ \text{s.t.} \quad & \sum_{\{f:p\in C(f)\}} d_{p,f} = 1; \ \ 0 \le d_{p,f} \le 1, \quad p \in C(f), \quad f \in \mathcal{F}. \end{aligned}$$

Lagrangean optimization readily gives that D_p^* contains a single element, namely

$$d_{p,f}^* = \left(\frac{1}{v_{p,f}^2}\right) \left(\sum_{\{f:p\in C(f)\}} \frac{1}{v_{p,f}^2} \right)^{-1}. \tag{4}$$

Thus the BLUE of the potential μ_p is

$$\widehat{\mu}_p = \sum_{\{f:p\in C(f)\}} d_{p,f}^* X_{p,f} = \sum_{\{f:p\in C(f)\}} \left(\frac{1}{v_{p,f}^2}\right) X_{p,f} \left(\sum_{\{f:p\in C(f)\}} \frac{1}{v_{p,f}^2} \right)^{-1}. \tag{5}$$

An unbiased estimator for the variance σ^2 is readily obtained from (3). For the BLUE $\widehat{\mu}_p$ an unbiased estimator for the variance, $\widehat{\sigma^2}$, is

$$\widehat{\sigma^2} = \frac{\sum_{p\in\mathcal{P}} \sum_{\{f:p\in C(f)\}} d_{p,f}^* ((X_{p,f} - \widehat{\mu}_p)^2)}{\sum_{p\in\mathcal{P}} \sum_{\{f:p\in C(f)\}} (d_{p,f}^* - (d_{p,f}^*)^2) v_{p,f}^2 / w_p^2}. \tag{6}$$

Observe that in the special case where all players are involved in all projects, we have $C(f) = \mathcal{P}$ and $\{f : p \in C(f)\} = \mathcal{F}$. Assuming that $w_p = 1$, and $v_{p,f} = 1$, we have

$d^*_{p,f} = 1/M$ for all p, f, and the BLUE is

$$\widehat{\mu}_p = \frac{1}{M} \sum_{f \in \mathcal{F}} X_{p,f}(t), \quad p \in \mathcal{P}.$$

Note that the label p is redundant, as all players are equivalent. An unbiased estimator for the variance, $\widehat{\sigma^2}$, is

$$\widehat{\sigma^2} = \frac{1}{M-1} \frac{1}{N} \sum_{p \in \mathcal{P}} \sum_{f \in \mathcal{F}} (X_{p,f}(t) - \widehat{\mu}_p)^2 = \frac{1}{M-1} \sum_{f \in \mathcal{F}} (X_{p,f}(t) - \widehat{\mu}_p)^2,$$

which coincides with the sample variance. □

4 A tool for distribution of subsidies by the Netherlands Film Fund

The Netherlands Film Fund is responsible for distribution of funds to support production of Dutch films [18]. To this end, a large share of the proposals by consortia are judged via peer review by consultants of the Netherlands Film Fund. Films are classified in various categories. For feature films, the Netherlands Film Fund distinguishes two categories: films targeted towards film festivals and commercial films targeted towards a broad audience.

To facilitate objective judgement, we have developed an objective ranking mechanism that measures the potential of proposals for new films. This mechanism is based on past performance of the film team (a producer, a director and a screenwriter) that submits a proposal for funding of the production of a film. Our mechanism takes into account and balances the artistic and box office achievements of the members of the production team. We tested the ranking mechanism with data of Dutch films, and parameters according to the policy of the Netherlands Film Fund, and it was concluded to provide fair rankings of producers, filmmakers and proposals.

4.1 Value of a film

The ranking mechanism is based on the value of a film represented in terms of box office revenues and awards at film festivals. To this end, in cooperation with the Netherlands Film Fund we developed a value function for films in the complete database of Dutch films. This value function takes into account the actual number of tickets sold and the artistic value via awards won at film festivals, where more points are obtained for an award at a more prestigious film festival. Table 1 gives an overview of film festivals and points.

Table 1: An overview of film festivals and the points for their awards.

Festival	2 points	4 points	6 points	8 points	10 points
British Academy of Film and Television Arts		Nomination best film / British film / not in English language, director, original screenplay		Award	
Berlin International Filmfestival	Official Generation competition (child and youth film competition) Out of Competition (out of competition, but main programme) Panorama (participation, out of competition) Forum of New Cinema (participation, out of competition)	Official competition Winner Generation competition Crystal Bear Winner First Feature Film		Golden Bear	
Festival de Cannes	Un Certain Regard (participation) Semaine de la Critique (participation) Quinzaine (participation)	Official competition Winner Semaine de la Critique / Critics Award Winner Camera d'Or first film (debut prize)			Palme d'Or
Cinekid	Cinekid Leeuw				
European Film Awards		Nomination		Award	
Golden Globe Awards		Nomination Best Foreign Film		Winner Golden Globe Best Foreign Film	
Film Festival Locarno	Participation in small competition (e.g. Swiss Air Cross Air prize)	Official competition	Golden Leopard		
Academy Awards	Short List		Nomination Best Foreign Film		Academy Award Best Foreign Film
Rome Film Festival	Participation	Award			
International Film Festival Rotterdam	Participation Tiger competition	Tiger Award			
San Sebastian International Filmfestival	Horizontes Zabaltegi (competition)	Official competition	Golden Shell		
Sundance Film Festival	Participation competition Participation competition Foreign Language	The Sundance/NHK International Filmmakers Award			
Tokyo International Film Festival	Participation competition	Award best director, Tokyo Sakura Grand Prix, Award for best artistic contribution			
Toronto International Film Festival	Participation				
Netherlands Film Festival (NFF)	Gouden Kalf best film, Gouden Kalf best director, Gouden Kalf best script, Gouden Kalf professionals award				
Venice Film Festival	Controcorrente (Upstream) Orizzonti Lion of the Future Venice days	Official competition Settimane della critica, FIPRESCI Award, Critics Award		Golden Lion	

The value function should be increasing in the number of visitors, where this increase is lower for larger numbers of visitors to take into account that it is more difficult to increase from say 50,000 to 100,000 visitors than from 900,000 to 1,000,000 visitors. The value function should also be increasing in the number of points for awards, where the increase is lower for larger numbers of points. Thus, the value function must be concave in both number of visitors and number of points for awards. Policy of the Netherlands Film Fund determines the exact weighing between the impact of the number of visitors and the number of points for awards. Furthermore, we have modified the value function to avoid disproportional effects of a film that receives a very low number of visitors or a very low number of award points (in the ranking of proposals this would have a disproportionally large effect on the potential of a filmmaker). For this, the minimal value is set to 2. Fitting to target values indicated by the Netherlands Film Fund, we selected the following formula for the value y_f of film f:

$$y_f = 10\left(1 - \frac{2}{10}^{(c_{1f}/500{,}000 + c_{2f}/4 + 0.231)}\right), \tag{7}$$

with c_{1f} the number of visitors/viewers, and c_{2f} the artistic score from awards of film f. Notice that 500,000 visitors or an artistic score of 4 points yield the same value: 8.6. For 1,000,000 visitors this value increases to 9.7, which is also obtained for 500,000 visitors and 4 artistic points. Note that policy of the Netherlands Film Fund determined three parameter values: (i) the rate of increase of the value y_f, determined by the factor 2/10, (ii) the weight of the number of visitors compared to the artistic points, determined by the numbers 500,000 and 4, and (iii) the minimal grade, determined by the start value 0.231. The multiplicative factor 10 is included to allow the value to be interpreted as a grade as used in the Dutch educational system. As an illustration, Table 2 gives the value for a number of films completed in 2010. We are not able to provide the most recent values (because of inavailability of information, and sensitivity of information with regard to subsidies). Our results in Section 4.5 clearly show the films that were most successful artistically or commercially in 2010, as in agreement with the expert judgement of the Netherlands Film Fund. Hence, the formula for y_f in equation (7) adequately captures the value of a film.

4.2 Potential of filmmakers

We adopt the model of Example 1 with normal noise. The player set $\mathcal{P}$ is the set of filmmakers (including producers). The value $x_{p,f}$ of player p in film f is determined by the value of the film and his profit share $\beta_{p,f}$ in this film, $x_{p,f} = \beta_{p,f} y_f$, $p \in C(f)$.

Table 2: An overview of the values of some Dutch films in 2010.

Film title	Visitors (c_{1f})	Artistic score (c_{2f})	Film value y_f
New Kids Turbo	1,087,933	0	9.79
Foeksia	279,321	2 (Cinekid Best Film)	8.75
Gelukkige huisvrouw	521,142	0 (Chigago International Festival New Director)	8.71
Joy	3,270	4 (Gouden Kalf best film, Gouden Kalf script)	8.64
Dik Trom	455,910	0	8.41
Loft	444,761	0	8.35
Tirza	184,564	2 (Troia International Film Festival, Gouden Kalf best director)	8.30
Briefgeheim	139,214	2 (Cinekid Best Dutch Film)	8.03
Sint	335,800	0	7.66
Lang en Gelukkig	26,375	2 (NFF Special jury prize, NFF public prize)	7.17

We *assume* that the value $X_{p,f}$ of film f of filmmaker (player) p discounted to time 0 is subject to less noise when filmmaker p is more experienced. Experience is gained in the projects in which a player participated. Experience obtained more periods ago is of less predictive value than recent experience. To represent this, we let the influence of experience on the value $X_{p,f}$ decay over time with a decay factor γ_w per period. The decay rates determine e.g. the half-life time of the influence of experience. If the half-life time is T years, then the corresponding decay rate is $\gamma_w = \sqrt[T]{1/2}$. The value for T is set by the Netherlands Film Fund.

Further, we assume that a filmmaker gathers more experience when his profit share $\beta_{p,f}$ in the film is larger. The current measure of the experience w_p of player p in period 0 is defined as

$$w_p^2 = \sum_{\{f:p\in C(f),\ t_f<0\}} \beta_{p,f}\gamma_w^{-t_f}.$$

Also, we *assume* that values of recent films are subject to less noise. Let noise decay over time with a factor γ_v per period. We *define* the current influence of the noise $v_{p,f}$ of film f completed in period t_f in the variance of $X_{p,f}$ by

$$v_{p,f}^2 = \gamma_v^{t_f}.$$

From (4) we obtain

$$d_{p,f}^* = \gamma_v^{-t_f}\left(\sum_{\{f:p\in C(f)\}} \gamma_v^{-t_f}\right)^{-1},$$

so that the BLUE (5) of the potential μ_p of filmmaker p is

$$\widehat{\mu}_p = \sum_{\{f:p\in C(f)\}} \gamma_v^{-t_f} X_{p,f} \left(\sum_{\{f:p\in C(f)\}} \gamma_v^{-t_f} \right)^{-1}, \quad p \in \mathcal{P}.$$

The variance σ^2 is estimated using the formula (6).

4.3 Evaluation of film proposals

A film proposal is usually made by a film team (coalition), consisting of three types : a producer, a director and a screenwriter. Quite often, several filmmakers of the same type cooperate. For example, a film team may have two cooperating producers. Let the value X_P resemble the joint value of the cooperating producers, and let $C_P(f)$ denote the set of producers in the filmteam of film f. Since production is a team effort, we consider the production team to be a (fictive) producer. We consider all films made by all producers in the production team, and let X_P be the value as if all those films were made by the fictive producer.

Similarly, we may define the sets $C_D(f)$, and $C_S(f)$ of directors and screenwriters of film f respectively. Since directors and screenwriters perform a large part of their task independently, their joint values X_D and X_S are determined as follows. Let the fraction $\delta_{p,f}$ denote the weight of director $p \in C_D(f)$, $\sum_{p\in C_D(f)} \delta_{p,f} = 1$. For example, if two directors cooperate, and one has no experience, we may set the weight of the unexperienced director to 0. This is the same as selecting the director with the larger value. The joint values X_D and X_S of directors and screenwriters are

$$X_D = \sum_{p\in C_D(f)} \delta_{p,f} X_{p,f}, \qquad X_S = \sum_{p\in C_S(f)} \delta_{p,f} X_{p,f}.$$

We may evaluate, or rank, film proposals according to $\mathbb{P}(V_f > c)$ with

$$V_f = \frac{\alpha_P X_P + \alpha_D X_D + \alpha_S X_S}{\alpha_P + \alpha_D + \alpha_S}, \tag{8}$$

where the constant c and the weights α_P, α_D, and α_S are determined by the Netherlands Film Fund.

4.4 Evaluation of individual filmmakers

Besides evaluating film proposals, we may also evaluate individual filmmakers. For this, we consider the current value of the filmmaker p as if he is the only member of the film

Table 3: Description of results of individual filmmakers, as used in Tables 4-6.

Description	Meaning
Recent	Released in the cinema less than 3 years ago, i.e. between January 1, 2008 and January 1, 2011.)
Box-office success	$200,000 \leq c_{1f} < 400,000$ (cinema visitors per film)
Decent box-office success	$400,000 \leq c_{1f} < 750,000$
Considerable box-office success	$750,000 \leq c_{1f}$
Artistic success	$2 \leq c_{2f} < 4$ (artistic score per film; Golden Calf awards and/or awards at smaller international festivals)
Decent artistic success	$4 \leq c_{2f} < 6$ (Golden Calf awards and/or awards like a Crystal Bear, etc.)
Considerable artistic success	$6 \leq c_{2f}$ (Golden Calf awards and/or a selection or awards at large international festivals)

team. Then his profit share is $\beta_{p,f} = 1$, and since we consider a film completed in the current time period $t_f = 0$, we have $v_{p,f}^2 = 1$. We may now evaluate filmmakers according to

$$\mathbb{P}(X_p > c),$$

where X_p is the current value of filmmaker p with mean μ_p and variance σ^2/w_p^2. The constant c is determined by the Netherlands Film Fund.

4.5 Implementation and results

We use data of Dutch films till 2011, cf. [5, 11, 15], and parameters $c = 5$, $T = 20$, $\gamma_v = \sqrt[T]{1/2}$, $\alpha_P = 3$, $\alpha_D = 2$, and $\alpha_S = 1$.

First we use our model to evaluate the individual filmmakers. Because this information is confidential, we do not mention the names of the filmmakers, but we describe their results as set out in Table 3. The ranking of top 10 producers is shown in Table 4. In the table we list the values $10\mathbb{P}(X_p > c)$ for each filmmaker p, which may be interpreted as grades. The rankings of top 10 directors and sreenwriters follow in Tables 5 and 6. These rankings are concluded to be fair rankings.

Furthermore, we estimate the values of Dutch films released in 2010 by evaluating these according to (8). The estimated and realised film values are based on data in Tables 8 and 9 in the Appendix. We compare these values in Table 7. Some films have an estimated film value more than two points below the realised film value. These differences are caused by debuting filmmakers: New Kids Turbo (debuting director and screenwriter), Gelukkige Huisvrouw (debuting director and screenwriter), Dik Trom (debuting director),

Table 4: Ranking of top 10 producers of Dutch films per 1/1/2011.

Description of producer	Value
Artistic, for large audiences	9.66
Exceptional artistic success	9.45
Mostly successful at the box office	9.32
Successful at festivals and at the box office	9.22
Successful at the box office	9.03
Almost always successful at the box office	8.95
Mostly successful at the box office, occasional a festival success	8.63
Often successful at the box office, occasional a festival success	8.42
A few films, often with box office success	8.41
Variation of big box office hits to decent ones with artistic success	8.35

Table 5: Ranking of top 10 directors of Dutch films per 1/1/2011.

Description of director	Value
Artistic, for large audiences	9.97
Classics, at the box office as well as at festivals	9.96
Guaranteed box office success and occasionally more than that	9.90
Significant artistic success	9.86
Box office success with authentic entertainment	9.83
Decent box office success and occasionally more than that	9.74
Succesful at box office and festivals	9.68
Multiple artistic and box office successes	9.68
Few films yet with either box office success or artistic success	9.63
Recent solid box office success	9.50

Table 6: Ranking of top 10 screenwriters of Dutch films per 1/1/2011.

Description of screenwriter	Value
Guaranteed box office success and occasionally more than that	9.83
Decades of authentic entertainment for large audiences	9.81
Classics, at the box office as well as at festivals	9.79
Decades of artistic success	9.68
Recent solid artistic success	9.27
Mostly decent artistic success	9.21
Involvement adds to box office success	9.13
Mostly successful at the box office	8.95
Few films, yet with considerable artistic success	8.94
Few films, yet all with artistic success	8.93

Loft (debuting director and screenwriter), and Ernst, Bobbie en het geheim van de Monta Rossa (debuting director and screenwriter).

To measure the quality of our estimations, we use the Theil U statistic [17], which is a measure to evaluate forecasts. If $\hat{y}_f$ denotes the estimated value of film f, then $U = \sqrt{\sum_f (y_f - \hat{y}_f)^2 / \sum_f y_f^2}$. This statistic has a value of $U = 0.42$, indicating that our estimates are good. Hence, our ranking mechanism is a useful tool for objective judgement of proposals for new films.

5 Conclusions

In this paper we introduced a new and objective method to measure the quality of proposals from collaborating players. The potential of a player is influenced by a random environment. We derive a (numerical) value of a proposal by collaborating players. Furthermore, we provide the best linear unbiased estimator of the potential of a player.

We applied our method to estimate the values of Dutch films released in 2010. Our method is shown to obtain good results. Therefore, it is a useful tool for objective judgement of proposals for new films. Furthermore, as a by-product we rank producers, directors and screenwriters of Dutch films. These rankings are concluded to be fair.

Our method may be used as a new selection method for proposals. Our model provides clear directives on which the selection is based. The application to Dutch films shows that experienced filmmakers get high values, and cooperation with new talented filmmakers is

Table 7: Estimated and realised film values for Dutch films in 2010. The Theil U statistic is 0.42, indicating that our estimates are good.

	Film value	
	Estimated ($\hat{y}_f$)	Realised (y_f)
New Kids Turbo	2.98	9.79
Joy	9.79	8.64
Foeksia	7.36	8.75
Gelukkige huisvrouw	2.98	8.71
Dik Trom	4.14	8.41
Loft	2.39	8.35
Tirza	6.80	8.30
Briefgeheim	8.64	8.03
Sint	9.92	7.66
Lang en Gelukkig	8.23	7.17
Iep	5.17	6.58
Sinterklaas en het pakjes mysterie	9.53	6.45
Eetclub	5.14	6.38
Het Geheim	7.90	6.24
Gangsterboys	4.61	5.61
Ernst, Bobbie en het geheim van de Monta Rossa	2.16	4.52
First Mission	2.54	3.95
Sterke Verhalen	2.41	3.78
Majesteit	2.90	3.63
Schemer	3.58	3.31
Kom niet aan mijn kinderen	2.18	3.29
Vliegenierster Kazbeck	5.20	3.27
Zwart water	2.11	3.25
Vreemd Bloed	3.11	3.20
Win	1.96	3.19
Shocking Blue	1.83	3.18
RU There	2.54	3.17
Richting West	4.60	3.17
Johan Primero	2.39	3.16
Bardsongs	2.53	3.14
Hunting & zn	2.06	3.13
C'est deja été	1.94	3.12
Great Kills Road	1.59	3.11
Vlees	1.39	3.11

encouraged.

Acknowledgements

We thank dr. Wilbert Kallenberg for inspiring discussions on the BLUE, and on statistics in general.

A Appendix

The results in Table 7 are based on the data of Dutch films in 2010 in Table 8, with the data used to estimate the film values, and in Table 9, to calculate the realised film values. In Table 8, the variance of a debuting filmmaker is set to 100.

Table 8: Estimated film values and data of Dutch films in 2010.

Film title	Producers	Directors	Screenwriters	Estimated film value	Potential film team	Variance film team
New Kids Turbo	Eyeworks Film &TV Drama	Steffen Haars, Flip van der Kuil	Steffen Haars, Flip van der Kuil	2.98	3.01	14.06
Joy	IDTV	Mijke de Jong	Helena van der Meulen	9.79	6.77	0.75
Foeksia	NL Film	Johan Nijenhuis	Sander de Regt	7.36	6.14	3.26
Gelukkige huisvrouw	Eyeworks Film &TV Drama	Antoinette Beumer	Marnie Blok, Karen van Holst Pellekaan	2.98	3.01	14.06
Dik Trom	Eyeworks Film &TV Drama	Arne Toonen	Wijo Koek, Mischa Alexander	4.14	4.27	11.35
Loft	Pupkin Film	Antoinette Beumer	Saskia Noort	2.39	2.19	15.72
Tirza	Fu Works, Cadenza Film	Rudolf van den Berg	Rudolf van den Berg	6.80	5.43	0.84
Briefgeheim	Lemming Film	Simone van Dusseldorp	Marco van Geffen, Anna van der Heide	8.64	6.34	1.49
Sint	Tom de Mol Producties, Parachute Pictures	Dick Maas	Dick Maas	9.92	7.01	0.69
Lang en Gelukkig	NL Film	Pieter Kramer	Don Duyns	8.23	6.74	3.52
Iep	Lemming	Rita Horst	Mieke de Jong	5.17	5.06	2.29
Sinterklaas en het pakjes mysterie	SRSP Films	Martijn van Nellestijn	Martijn van Nellestijn	9.53	7.25	1.81
Eetclub	Infinity Film & TV Productions	Robert jan Westdijk	Paul Jan Nelissen, Hugo Heinen	5.14	5.04	1.54
Het Geheim	IDTV Film	Joram Lrsen	Frank Ketelaar	7.90	5.69	0.72
Gangsterboys	Dutch Mountain Movies	Paul Ruven	Paul Ruven	4.61	4.89	1.17
Ernst, Bobbie en het geheim van de Monta Rossa	CTM Films	Pieter Walther Boer	Tijs van Marle	2.16	1.99	14.66
First Mission	IDTV Film	Boris Pavel Conen	Barbara Jurgens	2.54	2.52	13.98
Sterke Verhalen	Lagestee film	Kees van Nieuwkerk, Teddy Cherim	Kees van Nieuwkerk, Teddy Cherim	2.41	2.28	14.94
Majesteit	IDTV Film, Fu Works	Peter de Baan	Ger Beukekamp	2.90	3.13	11.44
Schemer	Lemming, Corrino Entertainment	Hanro Smitsman	Anjet Daanje	3.58	4.26	4.10
Kom niet aan mijn kinderen	Talented United	Ron Termaat	Nicolette Stergerda	2.18	1.65	18.48
Vliegenierster Kazbeck	Isabella Films	Ineke Smits	Arthur Japin	5.20	5.11	5.01
Zwart water	Accento Films	Elbert van Strien	Elbert van Strien	2.11	0.00	38.89
Vreemd Bloed	IDTV Film	Johan Timmers	Maria Goos	3.11	3.34	11.30
Win	IJswater Film	Jaap van Heusden	Jaap van Heusden	1.96	1.70	14.92
Shocking Blue	Waterland Film	Mark de Cloe	Celine Linssen	1.83	3.17	4.12
RU There	IDTV FILM	David Verbeek	Rogier de Blok	2.54	2.52	13.98
Richting West	KEY Film	Nicole van Kilsdonk	Nicole van Kilsdonk	4.60	4.81	3.63
Johan Primero	Pupkin Film	Johan Kramer	Johan Kramer	2.39	2.19	15.72
Bardsongs	Sander Francken Film	Sander Francken	Sander Francken, Joost Schrickx	2.53	1.59	26.21
Hunting & zn	NFI Productions	Sander Burger	Sander Burger	2.06	1.70	16.18
C'est deja été	De Productie	Martijn Smits	Bastiaan Kroeger, Martijn Smits	1.94	1.72	14.37
Great Kills Road	Phanta Vision	Tjebbo Penning	Tjebbo Penning	1.59	2.72	5.23
Vlees	De Productie	Maartje Seyferth, Victor Nieuwenhuis	Maartje Seyferth, Victor Nieuwenhuis	1.39	2.76	4.28

Table 9: Realised film values of Dutch films released in 2010.

Film title	Visitors	Awards	c_{2f}	Film value
New Kids Turbo	1087933			9.79
Foeksia	279321	Cinekid Best Film	2	8.75
Gelukkige huisvrouw	521142	Chigago International Festival New Director		8.71
Joy	3270	Gouden Kalf Beste Film, Gouden Kalf scenario	4	8.64
Dik Trom	455910			8.41
Loft	444761			8.35
Tirza	184564	Troia International Film Festival, Gouden Kalf regie.	2	8.30
Briefgeheim	139214	Cinekid Best Dutch Film	2	8.03
Sint	335800			7.66
Lang en Gelukkig	26375	NFF Speciale juryprijs, NFF publieksprijs	2	7.17
Iep	217960	Nominatie Beste Film Cinekid, Grand Prix Montreal, Busters Grand Prix		6.58
Sinterklaas en het pakjes mysterie	206208			6.45
Eetclub	200072			6.38
Het Geheim	187974	Buster Politiken audience award		6.24
Gangsterboys	140067			5.61
Ernst, Bobbie en het geheim van de Monta Rossa	71355			4.52
First Mission	40827			3.95
Sterke Verhalen	31915			3.78
Majesteit	24766			3.63
Schemer	9542	Dutch Critics Award		3.31
Kom niet aan mijn kinderen	8648			3.29
Vliegenierster Kazbeck	7336			3.27
Zwart water	6638	Fantasporto		3.25
Vreemd Bloed	4332			3.20
Win	3918	Prix Europa scenario, Brooklyn best actor		3.19
Shocking Blue	3498			3.18
RU There	3169			3.17
Richting West	2741			3.17
Johan Primero	2589			3.16
Bardsongs	1550			3.14
Hunting & zn	932			3.13
C'est deja été	605			3.12
Great Kills Road	237			3.11
Vlees	174			3.11

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